FOSSILIONTECH

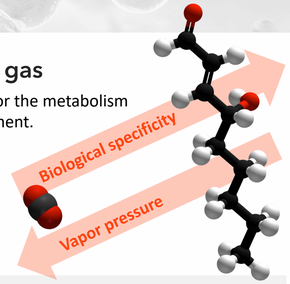
Detecting low volatility metabolites in the gas phase to resolve the time dimension of your metabolomic studies

Why measure low volatility metabolites in the gas

Detecting biomolecules in the gas phase is of great interest to monitor the metabolism of organisms that naturally release VOCs in the surrounding environment.

Large molecules carry more information, but they are often very diluted because large molecules have low vapor pressure.

We present SUPER SESI, an ionization interface specifically designed to detect molecules with very low vapor pressure at minute concentration in the gas phase.



The paradox

Current high end mass spectrometers have limits of detection (LoD) in the femto-mole range. In 1 liter of air, that amount of matter produces a partial pressure of **$2 \cdot 10^{-15}$ Bar**, Instruments specifically designed for the analysis of VOC's have LoD of **10^{-12} Bar.** Yet, vapor pressures of species normally reported in literature are much higher…

Aniline : **$5 \cdot 10^{-4}$ Bar** @ 36ºC, Methyl acetate: **$1.3 \cdot 10^{-4}$ Bar** @ 25ºC

There are at least 8 orders of magnitude missing!! that's a lot of room for improvement!!!

What limits what species are detectable? How can we improve this?

Aerosol condensation: If the partial pressure (P_p) of substance is higher than its vapor pressure (P_v), it condenses or form aerosols around condensation nuclei.
In order for the molecules of interest to be detectable in the gas, the partial pressure shall be lower than the vapor pressure. This inequality ($P_v > P_p$) divides the P_p-P_v diagram in two.

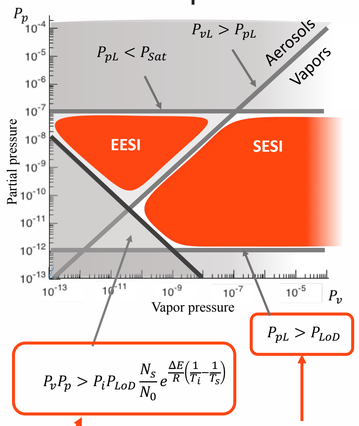
Instrument inherent LoD: if the MS requires, a minimum amount of ions, this translates into a minimum partial pressure in the gas: $P_p > P_{LoD}$

Saturation: maximum amount of molecules that can be handled: $P_p < P_{Sat}$

Memory effects and condensation in the flow path: When entering the analyzer, low volatility species condense onto the walls of the system. In order for a species to be detectable, the molecules desorbing from the walls of the system have to reach the LoD of the instrument (P_{LoD}) in the time available for the analysis. Equation (eq.1) illustrates this limitation in the P_p-P_v diagram,

$$P_v P_p > P_i P_{LoD} \frac{N_s}{N_0} e^{\frac{\Delta E}{R}\left(\frac{1}{T_i}-\frac{1}{T_s}\right)} \quad \text{(eq.1)}$$

* where P_i, T_i, are the pressure and temperature in the ionizer, T_s is the temperature in the sample where VOCs are being released, N_s is the number of molecules required to fully saturate the ionizer by condensation onto its walls, N_0 is the number of air molecules available for the analysis, R is the specific gas constant, and E is the specific vapor heat.



Improving N_s requires reducing the available exposed active areas.

Improving P_{LoD} requires better ionization efficiencies and ion transmission, and better background levels on the side of the ionizer.

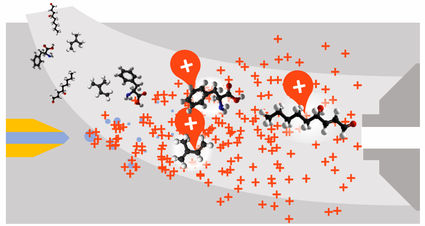
Secondary Electro-Spray Ionization SESI

An ideal technology for the detection of minute concentrations of low volatility species in the gas phase

Mechanism:

- Charging ions produced by nano-electrospray
- Analyte vapors through sample inlet
- Charge transfer reactions ionize analyte
- Ionized analyte transferred to MS

- High temperature, droplets rapidly evaporate
- The ionization mechanism is uniform and dominated by protonated clusters in equilibrium



Ionization efficiency

- Pressure, Reaction rate is proportional, coulombic dilution inversely proportional. The combined effect: concentration of analyte ions scales with the square of the pressure. The ionization efficiency is highly improved by operating at high pressure.

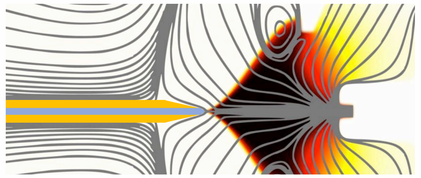
Analyte ion concentration | Reaction rate **(+)** | Coulombic dilution **(-)**

$$\frac{dn_a}{dt} = K_{ca} N_a n_c - n_a \nabla\left(Z_a \vec{E} + \vec{V_f}\right)$$

Concentration of analyte ions: $n_a \sim P^2$ | Concentration of neutral molecules $N_a \sim P$ | *Electric mobility of the ions:* $Z_a \sim 1/P$

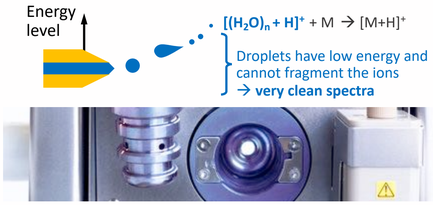
Optimized design:

- FIT's numerical simulation method integrates gas &ion dynamics, the nano-spray meniscus, charge reaction, and gas-ion exchange of momentum.
- This allowed us to simulate & optimize the configuration of the ionizer:
  - Minimize turbulence and dilution
  - Maximize transmission to the MS,
  - Minimize exposed surface



Limits of detection:

- Charging agents originate from nano-droplets. Non high energy ions involved means no fragmentation, and very clean spectra.
- Flow path designed to minimize accumulation of contaminants.
- Even tiny signals rise above low background

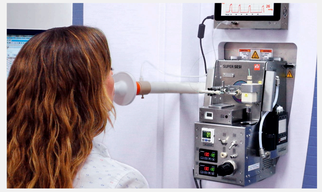


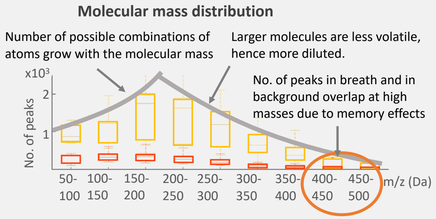
SUPER SESI

Compatible with
Thermo & Sciex
High Resolution
Mass Spectrometers

SESI Applications

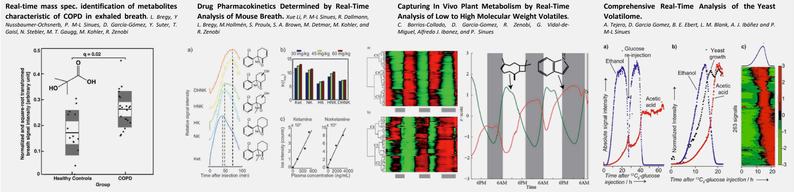
Detecting minute concentrations of vapors of relatively large metabolites in breath in real time*

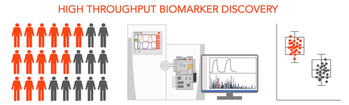




* For more details on breath analysis, visit our booth (704) or poster ThP 442

More Applications





We would like to know about your work. If you find this interesting, we would like to invite you to our booth (No. 704) and discuss about how we can help or cooperate with you :)